# Renewable Electricity Standard Economic Analysis

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April 5 2010
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The work presented here is a collaboration between Professor Berck, University of California, Berkeley and CAL ARB staff.

## Statewide Effects of:

- Increasing from 20% RPS to 33% RES
- In High and Low Load Cases
- With bundled REC's

## Economy Wide Model

- Find the effect on the total CA economy of the change from 20% to 33%.
- Use EDRAM, a general equilibrium model of CA
- What is EDRAM?

## Model History

- California State Senate Bill 1837 in 1994
- Evaluate Tax Bills Over $10 million
- Adopted by CAL EPA/ARB
  - SIP (2000 report)
  - Petroleum Reduction Strategies (joint with CEC)
  - Current SIP
- Continuous use for last 10 years in environmental regulation

# DRAM

- Captures all the fundamental economic relationships among consumers, producers and government.
- Computable
  - done numerically
  - over 1100 equations
- General Equilibrium
  - Prices adjust to clear markets
    - in factors, labor and capital
    - in goods and services
  - Conserves Money
  - Conserves goods, services, and factors

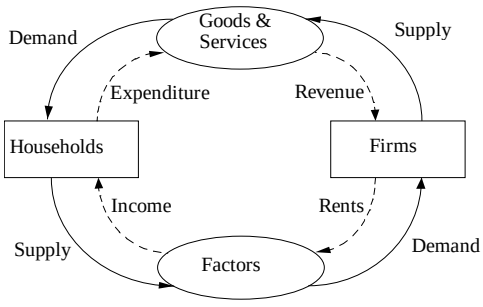
# Industrial Sectors

- Group like industries together
  - e.g. Agriculture sector represents all agricultural firms in CA.
    - output value = value of all crops in CA
    - labor demand = total value of labor used in ag.
- Data
  - national data Bureau of Economic Analysis
  - state employment data

# Households & Gov't

- 8 categories of HH
  - one for each marginal tax rate
  - traces income and expenditure for each
- Gov't
  - 7 federal, 27 state, and 11 local sectors
  - keeps program areas and tax types separate

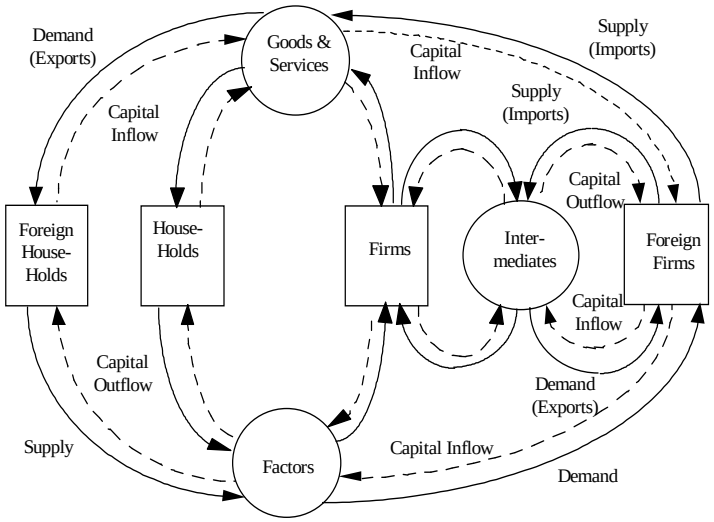
# Goods and Services




many different goods and services and many types of firms

Two Factors: Capital and Labor

## Trade and Intermediates




# Production

- Output is made from
  - Value added
    - which is made from capital and labor
  - and Intermediate Goods
- Producers Maximize Profits

## RES

- Operates on the technology, demand for intermediate goods
- For a MWH the amount of fossil fuel (gas) is reduced and the
- Amount of other inputs is increased.
- Changes demand for intermediate goods and cost of electricity

## Consumers

- Maximize their happiness by buying
  - goods and services
- Their income comes from
  - labor
  - capital
  - transfers (e.g. social security)
- They pay taxes

## Gov't and Trade

- Government has taxes as income
- Gov't buys goods and services
- Gov't makes transfer payments

## Trade

- When domestic prices increase relative to world prices, imports go up and exports go down.

## State Level Model

- (1) Regional CGE models do not require that regional savings equal regional investment.
- (2) Regional economies trade a larger share of their output.
- (3) Regional economies face larger and more volatile migration flows than nations.
- (4) Regional economies have no control over monetary policy.
- (5) In regional models, local, state and federal taxes are interdependent through deductibility.
- (6) There is less state specific data than there is national data.
- (7) the California CGE differs from a national CGE in that California faces a long run balanced-budget requirement.

## Back to RES

- For each load case we run the model twice
  - Once for 20%
  - Once for 33%
- Then find the difference in key macro numbers

# The measures

- First we look at how the actual measures like wind and solar get scaled up to meet the higher 33% target
- Left hand columns are 20% measures; Right hand 30%. These are measures needed to reach the standard.
- (we show the low load case)

| Resource | To Meet 20% | 20% Expend | 20% Savings | To Meet 33% | 33% Expenditure | 33%Savings |
|---|---|---|---|---|---|---|
| (2020 @ 20%) | (GWh) | (Billion $2008) | (Billion $2008) | (GWh) | (Billion $2008) | (Billion $2008) |
| Biogas | 223 | 0.023 | 0.023 | 2,078 | 0.203 | 0.219 |
| Biomass | 2,155 | 1.412 | 0.847 | 2,297 | 1.436 | 0.862 |
| Geothermal | 1,332 | 1.438 | 1.468 | 10,127 | 2.529 | 2.396 |
| Hydro - Small | 157 | 0.587 | 0.446 | 177 | 0.59 | 0.448 |
| Solar PV | 438 | 0.102 | 0.046 | 6,471 | 1.506 | 0.682 |
| Solar Thermal | 261 | 0.185 | 0.1 | 12,815 | 2.607 | 1.424 |
| Wind | 14,084 | 2.169 | 2.197 | 17,135 | 2.493 | 2.519 |
| Total | 18,650 | 5.915 | 5.129 | 51,099 | 11.364 | 8.55 |
| Total Change in Savings - Costs | | | | | | -2.028 |

# Then

- We look at the percent of incremental purchases from each measure by model sector
  - If we buy $100 more of solar
    - How much more of manufacturing
    - How much more of construction?

# Distribution of Cost to EDRAM Sectors

| Renewables | AGRIC | CONNON | MTLFAB |
|---|---|---|---|
| Biogas | 0% | 50% | 50% |
| Biomass | 23% | 27% | 50% |
| Geothermal | 0% | 50% | 50% |
| Hydro - Small | 0% | 35% | 65% |
| Solar PV | 0% | 35% | 65% |
| Solar Thermal | 0% | 35% | 65% |
| Wind | 0% | 25% | 75% |

Connon is construction; mtlfab is metal fabrication

# Difference from 20% to 33%

Aggregate Increment in the Low Load Scenario (20%) as input to EDRAM

| To-Sector | From-Sector | Aggregate Increment ($ Billion) |
|---|---|---|
| AGRIC | DISTEL | 0.325 |
| CONNON | DISTEL | 1.960 |
| MTLFAB | DISTEL | 3.631 |
| OILGAS | DISTEL | -5.129 |

Aggregate Increment in the Low Load Scenario (33%) as input to EDRAM

| To-Sector | From-Sector | Aggregate Increment ($ Billion) |
|---|---|---|
| AGRIC | DISTEL | 0.330 |
| CONNON | DISTEL | 4.023 |
| MTLFAB | DISTEL | 7.011 |
| OILGAS | DISTEL | -8.550 |

Connon is construction; Mtlfab is metal fabrication; Distel is electricity

# Natural Gas Output

- Model includes the shocks above
- And holds output of natural gas constant so that all decrease in demand is a decrease in imports.

# Low Load

| | 20% RPS | 33% RES | Diff. | % Diff. |
|---|---|---|---|---|
| Output ($Billion) | 3789.36 | 3789.54 | 0.18 | 0.00% |
| Gross state product (GSP, $Billion) | 2687.20 | 2687.65 | 0.45 | 0.02% |
| State personal income (SPI, $Billion) | 2173.60 | 2173.66 | 0.05 | 0.00% |
| Employment (Million) | 18.428 | 18.429 | 0.001 | 0.00% |

# High Load

| | 20% RPS | 33% RES | Diff. | % Diff. |
|---|---|---|---|---|
| Output ($Billion) | 3790.06 | 3791.15 | 1.09 | 0.03% |
| Gross state product (GSP, $Billion) | 2687.99 | 2689.37 | 1.38 | 0.05% |
| State personal income (SPI, $Billion) | 2174.12 | 2174.79 | 0.67 | 0.03% |
| Employment (Million) | 18.430 | 18.434 | 0.003 | 0.02% |

## Major Sectoral Consequences

- Construction and Manufacturing are expanded.
- Electricity distribution declines
  - Out of state sales decline;
  - Wouldn't be true if trading partners also had RES of 33%.

## Conclusion

- Higher cost of renewables is a negative.
- Import substitution is a positive.
- Avoidance of natural gas imports outweighs the higher cost of production making the RES 33% a slight advantage for the CA economy.